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(54) **SYSTEM AND METHOD FOR ASSOCIATING RELATED RECORDS TO COMMON ENTITIES ACROSS MULTIPLE LISTS**

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CPC ... ***G06F 17/30598*** (2013.01); ***G06F 17/30303*** (2013.01); ***G06F 17/30495*** (2013.01); ***G06F 17/30539*** (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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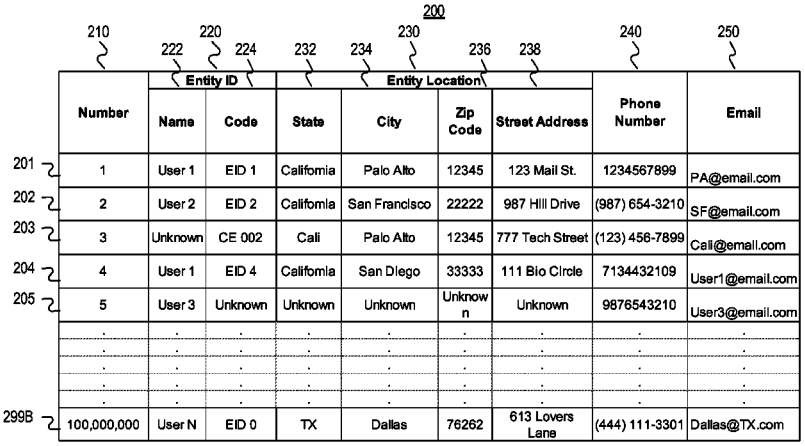
(57) **ABSTRACT**

Computer implemented systems and methods are disclosed for associating records across lists, wherein the lists include a plurality of records and the plurality of records is associated with a respective entity. In accordance with some embodiments, the systems and methods further comprise grouping one or more records from a first list into a first group based on fields of the records in the first list, grouping one or more records from a second list into a second group based on fields of the records in the second list, pairing a record from the first group with a record from the second group, assessing each pair of records based on an evaluation of the respective pair according to fields of the pair, and associating records from the first group and records of the second group with an entity based on the assessment.

17 Claims, 8 Drawing Sheets



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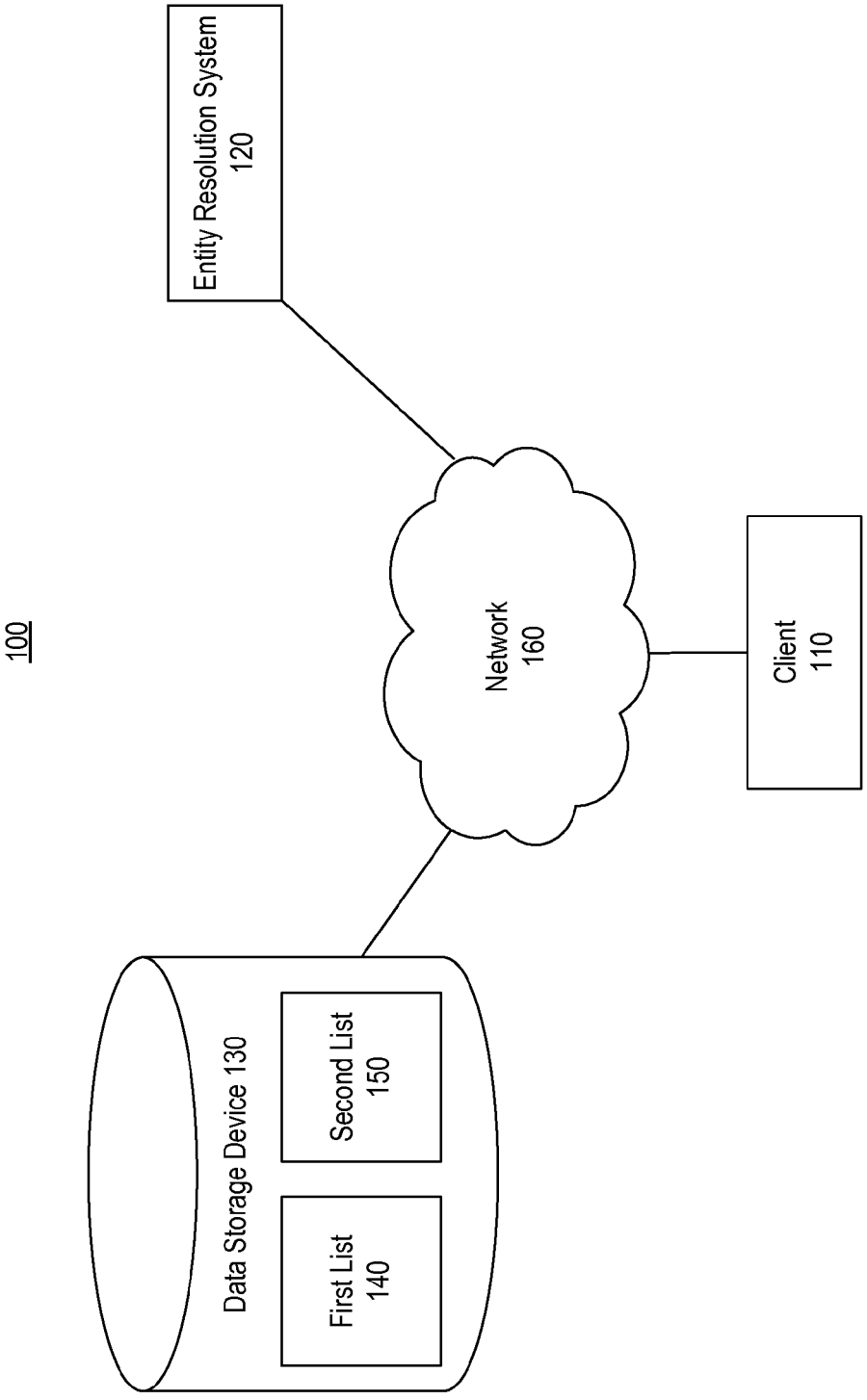
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FIG. 1

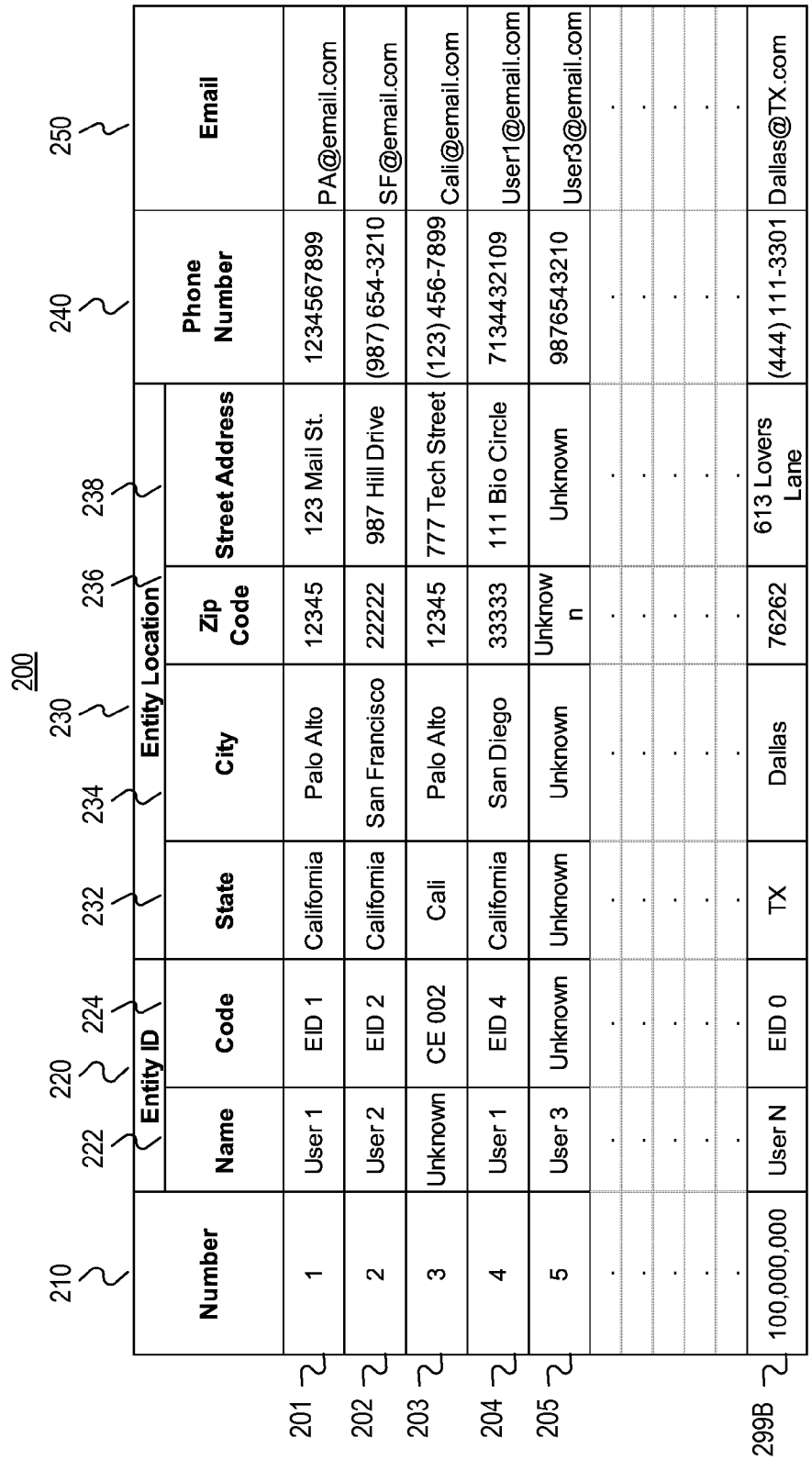
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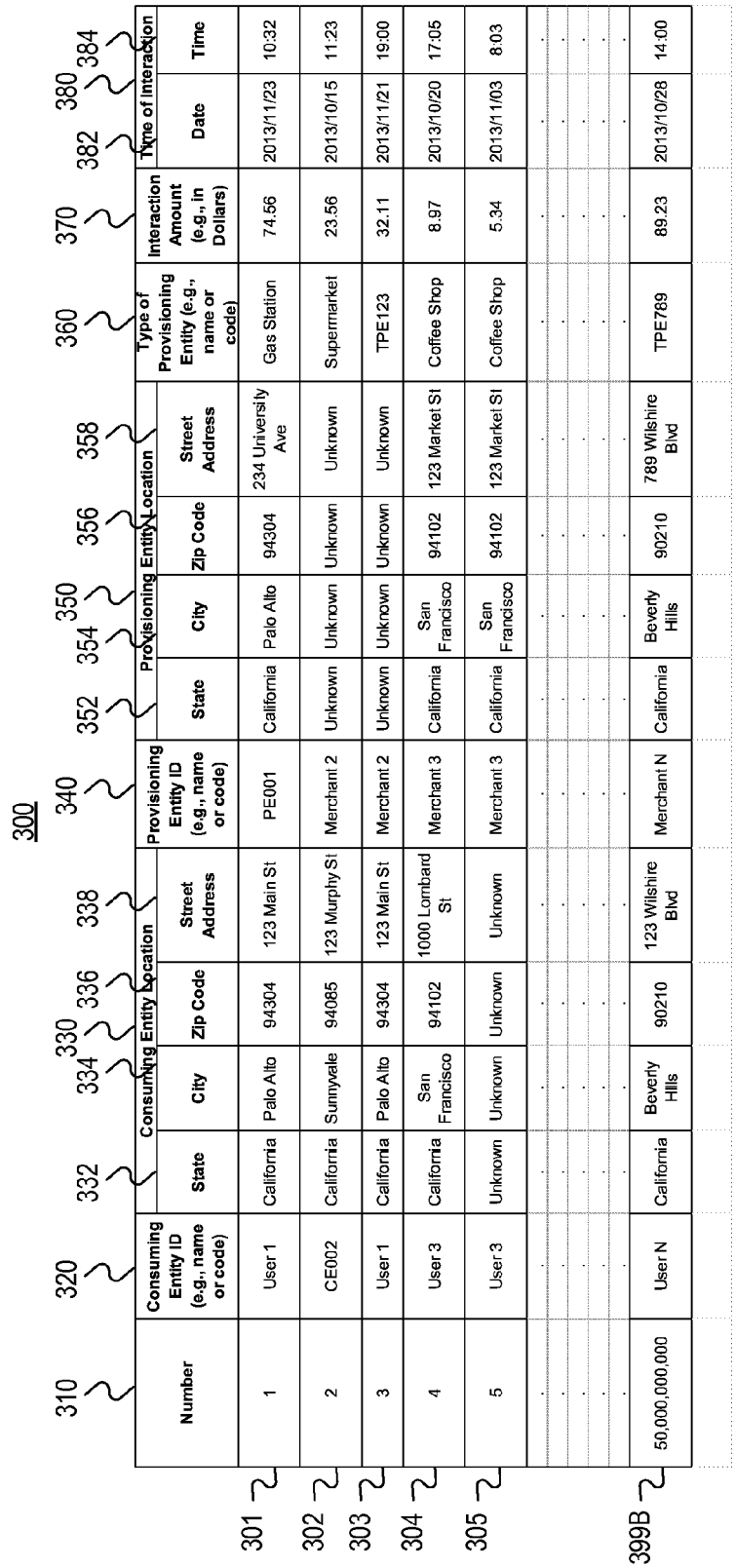
FIG. 2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Street Address
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Date
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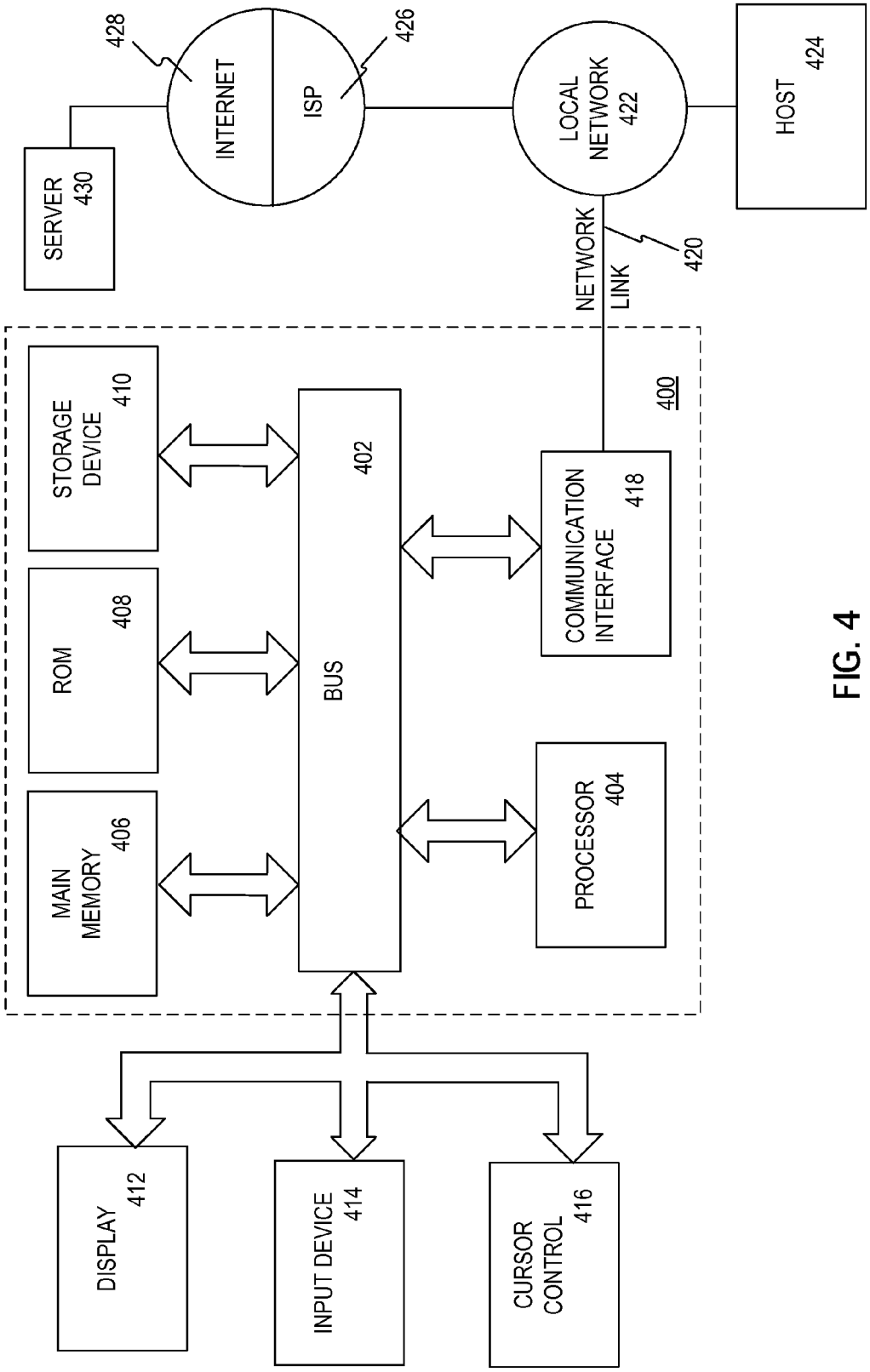
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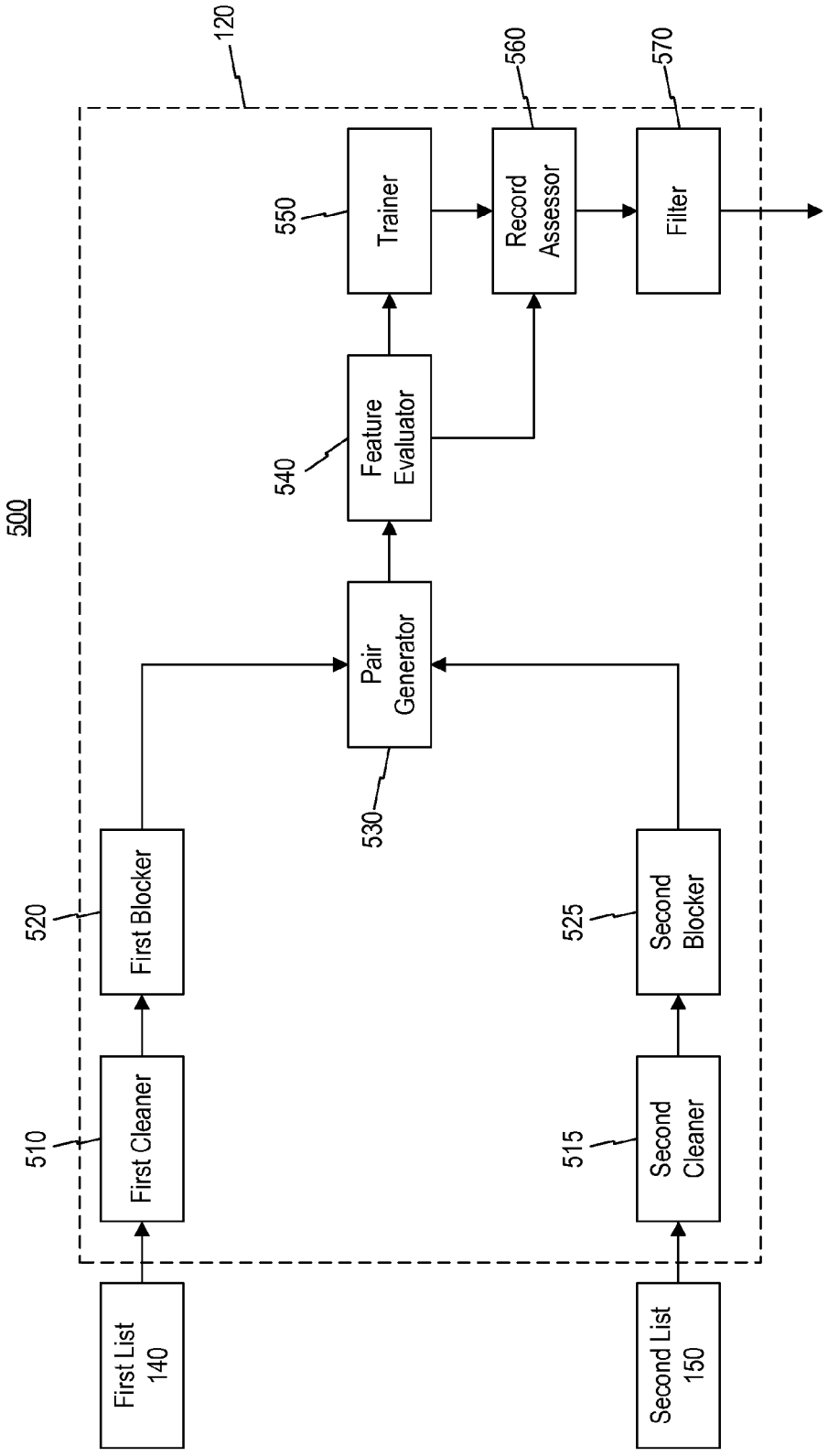
FIG. 4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First Cleaner
Second Cleaner
First Blocker
Second Blocker
Pair Generator
Feature Evaluator
Trainer
Record Assessor
Filter
510
515
520
525
530
540
550
560
570

FIG. 5

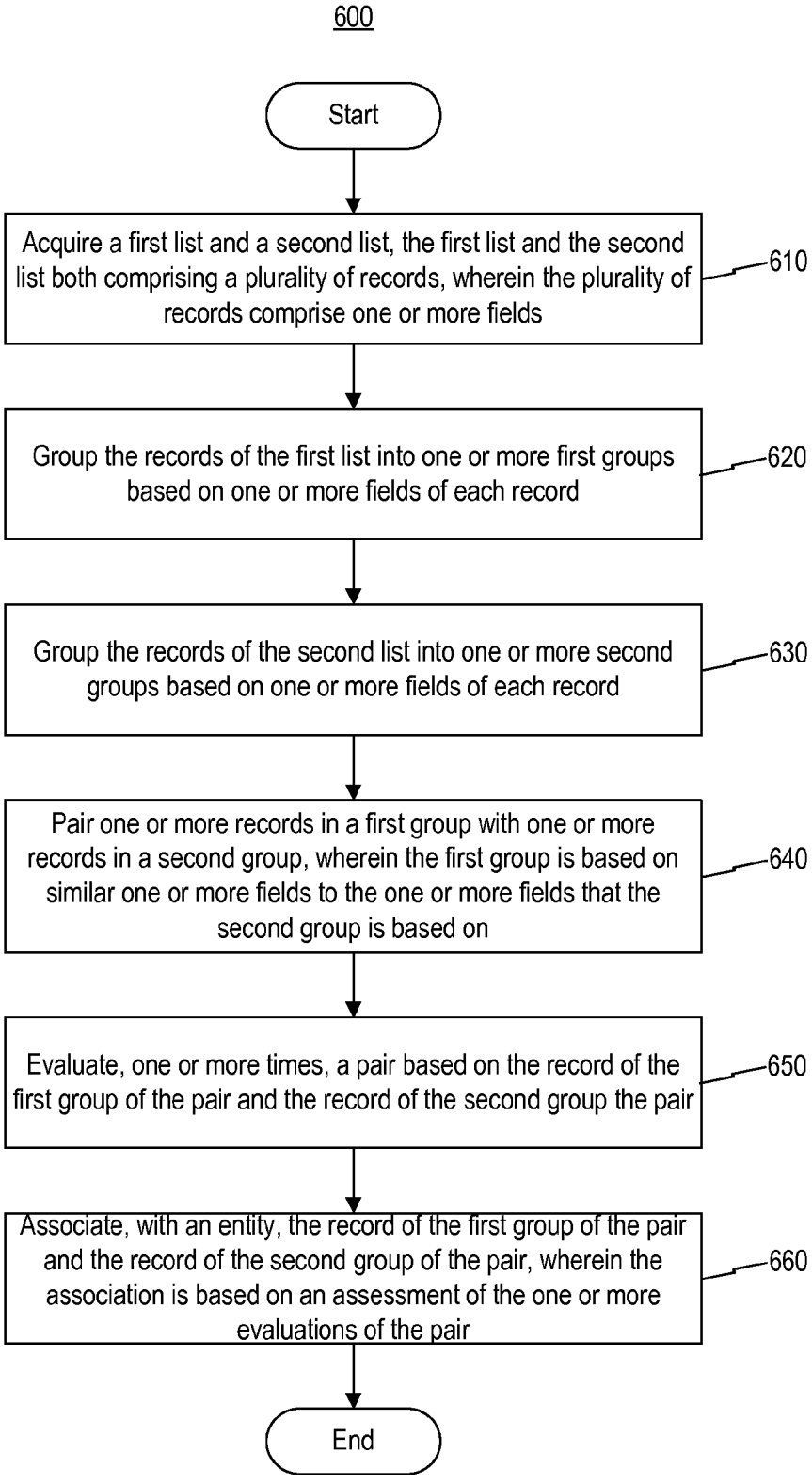
600
Start
Acquire a first list and a second list, the first list and the second list both comprising a plurality of records, wherein the plurality of records comprise one or more fields
610
Group the records of the first list into one or more first groups based on one or more fields of each record
620
Group the records of the second list into one or more second groups based on one or more fields of each record
630
Pair one or more records in a first group with one or more records in a second group, wherein the first group is based on similar one or more fields to the one or more fields that the second group is based on
640
Evaluate, one or more times, a pair based on the record of the first group of the pair and the record of the second group the pair
650
Associate, with an entity, the record of the first group of the pair and the record of the second group of the pair, wherein the association is based on an assessment of the one or more evaluations of the pair
660
End

FIG. 6

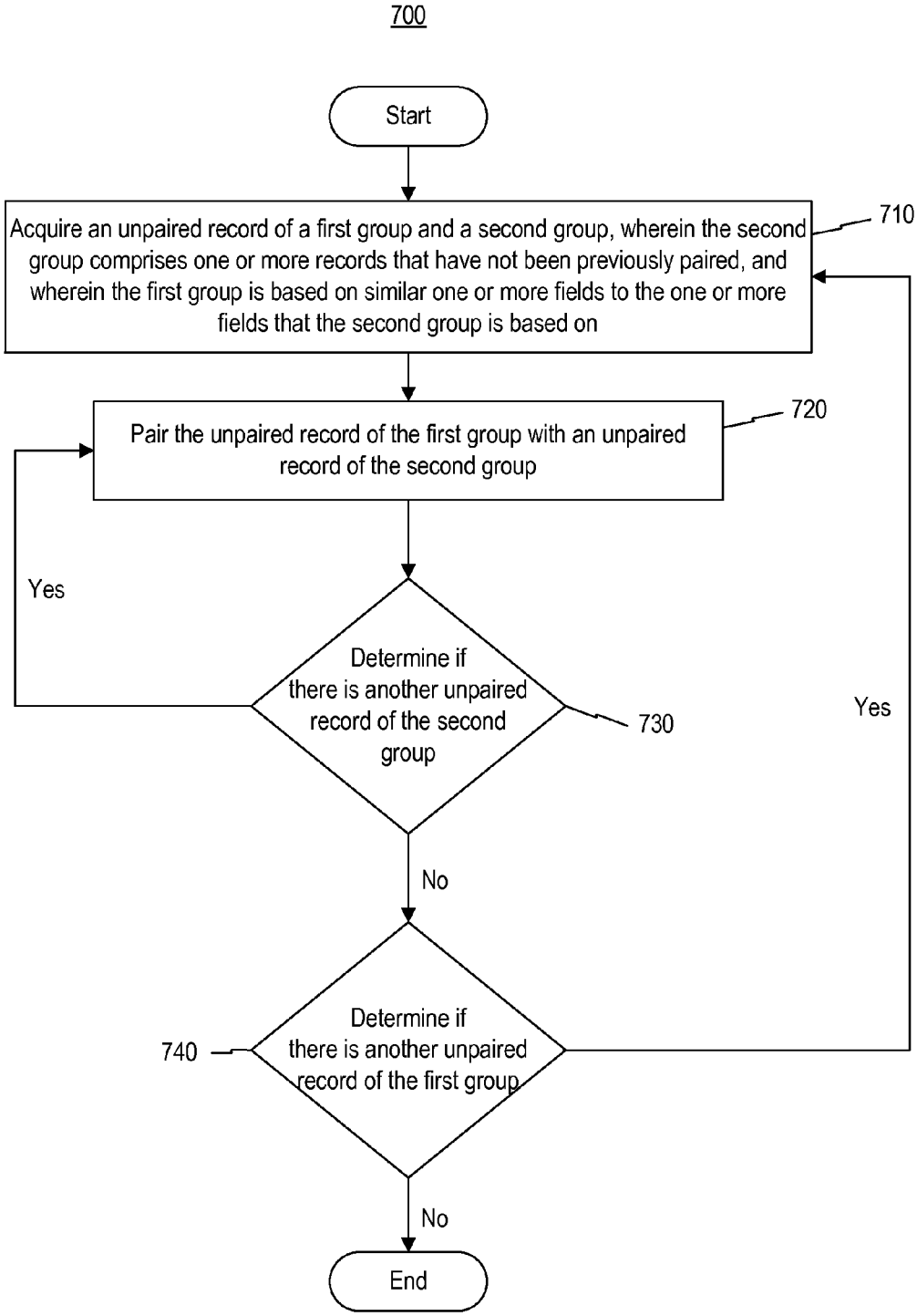
700
Start
Acquire an unpaired record of a first group and a second group, wherein the second group comprises one or more records that have not been previously paired, and wherein the first group is based on similar one or more fields to the one or more fields that the second group is based on
710
Pair the unpaired record of the first group with an unpaired record of the second group
720
Yes
Determine if there is another unpaired record of the second group
730
Yes
No
Determine if there is another unpaired record of the first group
740
No
End

FIG. 7

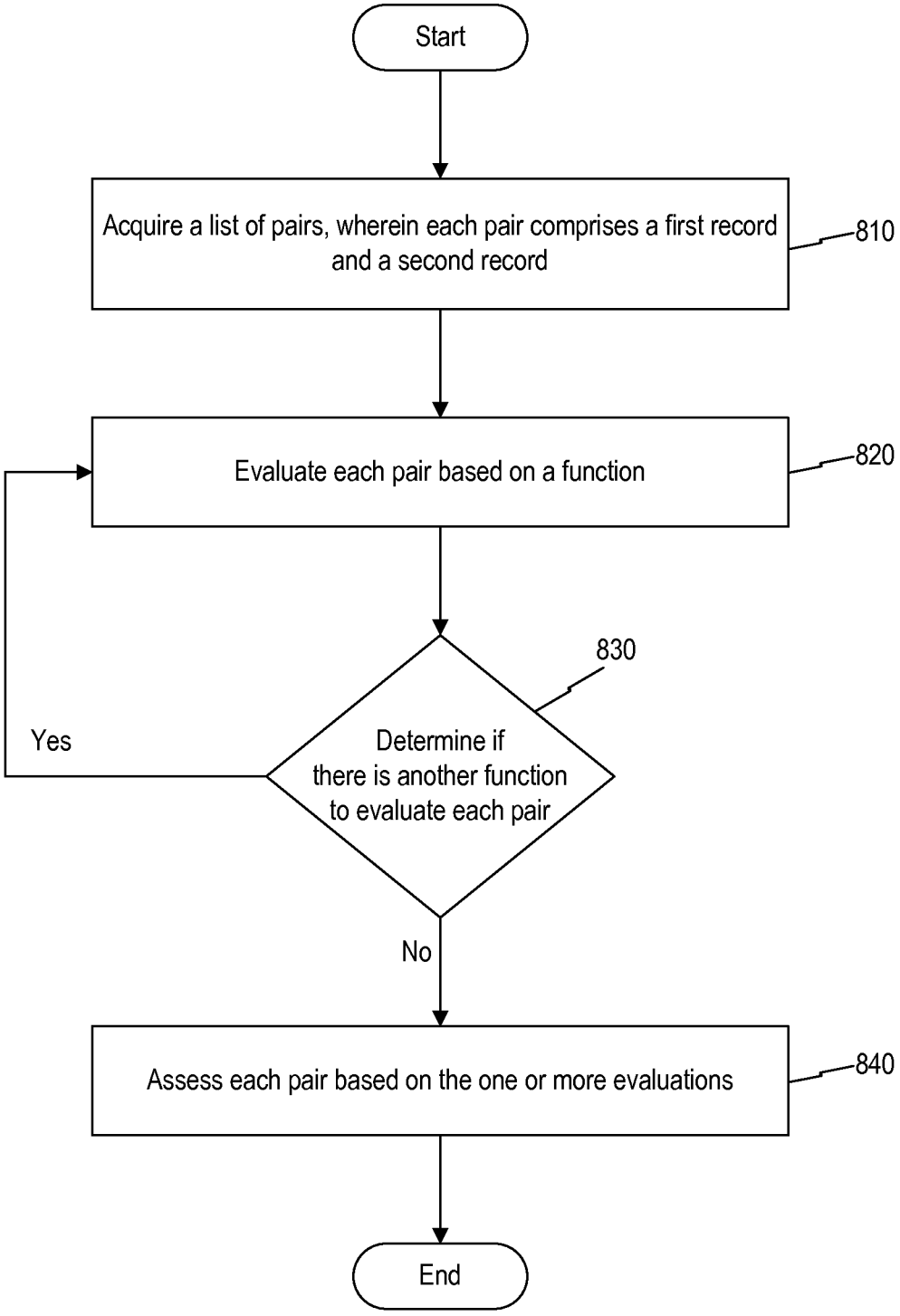
Start
Acquire a list of pairs, wherein each pair comprises a first record and a second record
810
Evaluate each pair based on a function
820
830
Determine if there is another function to evaluate each pair
Yes
No
Assess each pair based on the one or more evaluations
840
End

FIG. 8

SYSTEM AND METHOD FOR ASSOCIATING RELATED RECORDS TO COMMON ENTITIES ACROSS MULTIPLE LISTS

BACKGROUND

Obtaining relevant information from multiple large lists of records can be relatively straightforward in some situations. One particular situation is when records in separate lists are similar and it is desired to obtain information in the records having a particular value or character string in a particular field. The fields at issue can be isolated using filtering functions of data interfacing software and the desired information retrieved. By using combinations of filtering functions, more sophistication can be provided to the way in which fields are identified for comparison. Once compared, some records can be isolated based on the comparisons on the particular fields. The isolated records can then be aggregated so as to provide a report including all the records that together constitute the desired information.

But in order to recognize common records, such filtering functions rely on identical fields across the records. In the real world, lists may have no identical fields across the records, despite those records being related, or can have identical fields in a relatively small number of fields (or parts of fields) such that existing filtering functions are unable to provide isolation of the desired records from other records. For example, such problems can occur when a list has records originating from a number of different sources. This problem only worsens as the size of lists becomes larger (e.g., a list having billions of records), in terms of the number of records present. With the sizes of lists in the real world increasing as time progresses, this problem is expected to worsen over time.

BRIEF DESCRIPTION OF THE DRAWINGS

Reference will now be made to the accompanying drawings, which illustrate exemplary embodiments of the present disclosure and in which:

FIG. **1** is a block diagram of an exemplary system for associating related records to common entities across multiple lists, consistent with embodiments of the present disclosure.

FIG. **2** is a block diagram of an exemplary first list, consistent with embodiments of the present disclosure.

FIG. **3** is a block diagram of an exemplary second list, consistent with embodiments of the present disclosure.

FIG. **4** is a block diagram of an exemplary computer system, consistent with embodiments of the present disclosure.

FIG. **5** is a block diagram representing an exemplary process for associating related records to common entities across multiple lists, consistent with embodiments of the present disclosure.

FIG. **6** is a flowchart representing an exemplary method for associating related records to common entities across multiple lists, consistent with embodiments of the present disclosure.

FIG. **7** is a flowchart representing an exemplary method for pairing one or more records of a first group with one or more second groups, consistent with embodiments of the present disclosure.

FIG. **8** is a flowchart representing an exemplary method for evaluating and assessing one or more pairs, consistent with embodiments of the present disclosure.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Reference will now be made in detail to exemplary embodiments, the examples of which are illustrated in the accompanying drawings. Whenever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

Embodiments describe methods, systems, and non-transitory computer-readable mediums for associating related records to common entities across multiple lists. As stated previously, the one or more lists of data may be large, for example having billions of records. Some embodiments of the application can associate records that may not have useful identical fields while still excluding unrelated records, resulting in the association of records that relate to a common entity. Moreover, some embodiments of this application allow multiple lists of records that have no identical fields, but belong to the same common entity, to be associated to the common entity.

Further, some embodiments reduce the number of comparisons between multiple lists. With prior techniques, when a user desired to compare fields in multiple lists, every record in each list needed to be compared to every record in the every other list. With some embodiments of this application, merely relevant records in each list are compared together.

For example, assuming a first list comprises records that identify a plurality of entities by a distinct ID field and a second list identifies records from a plurality of sub-entities, each with a distinct ID, of the plurality of entities. In some embodiments, a system can associate all of the sub-entities of the second list with the entities of the first list.

FIG. **1** is a block diagram of an exemplary system **100** for associating related records to common entities across multiple lists, consistent with embodiments of the present disclosure. As shown, exemplary system **100** includes a client **110**, an entity resolution system **120**, and a data storage device **130**, which includes a first list **140** and a second list **150**. Further, client **110**, entity resolution system **120**, and data storage device **130** can communicate over a network **160**.

First list **140** and second list **150** can include data records, each having a number of fields. Examples of first list **140** and second list **150** are shown in FIGS. **2** and **3**, respectively. Data storage device **130**, however, does not need to include only first list **140** and second list **150**. Data storage device **130** can include any numbers of lists, including only one list that would represent both first list **140** and second list **150**. Also, exemplary system **100** can include more than one data storage device **130**. In the case of more than one data storage device **130**, first list **140** and second list **150** can be in different data storage devices or can be in the same data storage device.

First list **140** and second list **150** can be any type of list, including a data structure, or part of a data structure, a database, or part of a database. Some examples of data structures are arrays, tuples, hash tables, sets, graphs, queues, stacks, etc. An example of a database is a Relational Database Management System (RDBMS) that stores the transaction data as rows in relational tables. Alternatively, first list **140** and second list **150** can be a column-oriented database management system that stores data as sections of columns of data rather than rows of data. This column-oriented DBMS can have advantages, for example, for data warehouses, customer relationship management systems, and library card catalogues, and other ad hoc inquiry sys-

tems where aggregates are computed over large numbers of similar data items. A column-oriented DBMS can be more efficient than an RDBMS when an aggregate needs to be computed over many rows but only for a notably smaller subset of all columns of data, because reading that smaller subset of data can be faster than reading all data. A column-oriented DBMS can be designed to efficiently return data for an entire column, in as few operations as possible. A column-oriented DBMS can store data by serializing each column of data of first list **140** and second list **150**. First list **140** and second list **150** do not need to be the same type of list.

Client **110** can include one or more software applications configured to present data and translate user inputs into requests for record association by entity resolution system **120**. Client **110** can also run on entity resolution system **120**. In any event, a user would interact with exemplary system **100** through client **110**. And while client **110** is shown in FIG. **1**, it is appreciated that multiple clients can interact with data storage device **130** and entity resolution system **120**.

Entity resolution system **120** can be a computing system configured to associate related records to common entities across multiple lists. For example, entity resolution system **120** can be a computer system configured to execute software or a set of programmable instructions that collect or receive records from different lists and process those records to associate related records to common entities that may not have useful identical fields while still excluding unrelated entity records, resulting in the identification of entity records that relate to a common entity. In some embodiments, entity resolution system **120** can be implemented using a computer system **400**, as shown in FIG. **4** and described below.

Entity resolution system **120** can include one or more computing devices (e.g., server(s)), memory storing data and/or software instructions (e.g., database(s), memory device(s), etc.), and other known computing components. According to some embodiments, entity resolution system **120** can include one or more networked computers that execute processing in parallel or use a distributed computing architecture. Entity resolution system **120** can be configured to communicate with one or more components of system **100**, and it can be configured to provide entity resolution information via an interface(s) accessible by users over a network (e.g., the Internet). For example, entity resolution system **120** can include a web server that hosts a web page accessible through network **160**. In some embodiments, entity resolution system **120** can include an application server configured to provide data to one or more client applications executing on computing systems connected to entity resolution system **120** via network **160**.

Entity resolution system **120** can read data from multiple lists (e.g., first list **140** and second list **150**) from one or more data storage devices (e.g., data storage device **130**. Entity resolution system **120** can store resolution data on at least one of client **110**, entity resolution system **120**, data storage device **130**, first list **140**, and second list **150**.

Entity resolution system **120** can use the resolution data to associate records retrieved from first list **140** and second list **150**. Entity resolution system **120** can also pair the records from first list **140** and second list **150**. Entity resolution system **120** can use the pairs to provide insights about a particular entity.

FIG. **2** is a block diagram of an exemplary first list **140**, consistent with embodiments of the present disclosure. First list **140** can store records associated with entities. As shown in FIG. **2**, first list **140** can include a very large number of records. For example, first list **140** includes 100 billion records. While each record of first list **140** is depicted as a separate row in FIG. **2**, it will be understood that each such record can be represented in other ways, for example, by a column or any other technique in the art. Also, first list **140** can include duplicate entities or duplicate sub-entities, as shown in rows **201** and **204**. Each record can include several categories of information. For example, first list **140** includes: number category **210**; entity identification category **220**; entity location category **230**; phone number category **240**; and email category **250**. It will be understood that FIG. **2** is merely exemplary and that first list **140** can include more or less categories of information associated with a record.

Number category **210** can uniquely identify each record of first list **140**. For example, first list **140** depicts 100 billion records as illustrated by number category **210** of the last row of first list **140** as 100,000,000,000. It will be understood that this disclosure is not limited to any number of records and further that this disclosure can extend to a list with more or less than 100 billion records. It is also appreciated that number category **210** need not exist in first list **140**.

Entity identification category **220** can identify an entity. In some embodiments, entity identification category **220** can represent the entity identification by providing at least one of: a name of the entity (e.g., name sub-category **222**; User **1** for record **201**; unknown for record **203**); a code uniquely identifying the entity (e.g., code sub-category **224**; EID**1** for record **201**; unknown for record **205**). For example, the identifiers under entity identification category **220** can be a credit card number that can identify a person or a family, a social security number that can identify a person, a phone number or a MAC address associated with a cell phone of a user or family, or any other identifier.

Entity location category **230** can represent location information of the entity. In some embodiments, entity location category **230** can represent the location information by providing at least one of: a state of residence of the entity (e.g., state sub-category **232**; California for record **201**; unknown for record **205**); a city of residence of the entity (e.g., city sub-category **234**; Palo Alto for record **201**; unknown for record **205**); a zip code of residence of the entity (e.g., zip code sub-category **236**; **12345** for record **201**; unknown for record **205**); and a street address of residence of the entity (e.g., street address sub-category **238**; 123 Main Street for record **201**; unknown for record **205**).

Phone number category **240** can identify an entity's phone number. The phone number can be a character sequence. The character sequence can comprise of numbers, letters, spaces, or symbols, which can include "(, " ")," "-," and "-." For example, phone number category **240** of record **201** is 1234567899, while phone number category **240** of record **302** is (987) 654-3210. Also, the phone number can be unknown. The phone number provides a way for the entity to be contacted over a phone. It would be recognized by a person of ordinary skill in the art that a phone number is not only for connecting over a phone.

Email category **250** can identify an entity's email address. The email address should include a sequence of numbers and letters followed by an "@" symbol. After the "@" symbol will be another sequence of numbers and letters followed by a period and another sequence of numbers and letters. For example, email category **250** of record **201** is sf@email.com. The email address can be unknown. The email address provides a way for the entity to be contacted

over the internet. It would be recognized by a person of ordinary skill in the art that an email address is not only for connecting over the internet.

FIG. **3** is a block diagram of an exemplary second list **150**, consistent with embodiments of the present disclosure. Second list **150** can store data records associated with records involving multiple entities. As shown in FIG. **3**, second list **150** can include data associated with a very large number of records associated with multiple entities. For example, second list **150** can include 50 billion records. While each record of second list **150** is depicted as a separate row in FIG. **3**, it will be understood that each such record can be represented in other ways, for example, by a column or any other technique in the art. Each record can include several categories of information. For example, the several categories can include, number category **310**; consuming entity identification category **320**; consuming entity location category **330**; provisioning entity identification category **340**; provisioning entity location category **350**; type of provisioning entity category **360**; record amount category **370**; and time of record category **380**. It will be understood that FIG. **3** is merely exemplary and that second list **150** can include more or less categories of information associated with a record.

Number category **310** can uniquely identify each record of second list **150**. For example, second list **150** depicts 50 billion record as illustrated by number category **310** of the last row of second list **150** as 50,000,000,000. In FIG. **3**, each row depicting a record can be identified by an element number. For example, record number 1 can be identified by element **301**; record number 2 can be identified by element **302**; and so on such that record 50,000,000,000 can be identified by **399**B. It will be understood that this disclosure is not limited to any number of records and further that this disclosure can extend to lists with more or less than 50 billion records. It is also appreciated that number category **310** need not exist in second list **150**.

Consuming entity identification category **320** can identify a consuming entity. In some embodiments, consuming entity identification category **320** can represent a name (e.g., User **1** for record **301**; User N for record **399**B) of the consuming entity. Alternatively, consuming entity identification category **320** can represent a code uniquely identifying the consuming entity (e.g., CE**002** for record **302**). For example, the identifiers under the consuming entity identification category **320** can be a credit card number that can identify a person or a family, a social security number that can identify a person, a phone number or a MAC address associated with a cell phone of a user or family, or any other identifier.

Consuming entity location category **330** can represent location information of the consuming entity. In some embodiments, consuming entity location category **330** can represent the location information by providing at least one of: a state of residence (e.g., state sub-category **332**; California for element **301**; unknown for record **305**) of the consuming entity; a city of residence (e.g., city sub-category **334**; Palo Alto for record **301**; unknown for record **305**) of the consuming entity; a zip code of residence (e.g., zip code sub-category **336**; **94304** for record **301**; unknown for record **305**) of the consuming entity; and a street address of residence (e.g., street address sub-category **438**; 123 Main St. for record **301**; unknown for record **305**) of the consuming entity.

Provisioning entity identification category **340** can identify a provisioning entity (e.g., a merchant or a coffee shop). In some embodiments, provisioning entity identification category **340** can represent a name of the provisioning entity (e.g., Merchant **2** for record **302**). Alternatively, provisioning entity identification category **340** can represent a code uniquely identifying the provisioning entity (e.g., PE**001** for record **301**). Provisioning entity location category **350** can represent location information of the provisioning entity. In some embodiments, provisioning entity location category **350** can represent the location information by providing at least one of: a state where the provisioning entity is located (e.g., state sub-category **352**; California for record **301**; unknown for record **302**); a city where the provisioning entity is located (e.g., city sub-category **354**; Palo Alto for record **301**; unknown for record **302**); a zip code where the provisioning entity is located (e.g., zip code sub-category **356**; **94304** for record **301**; unknown for record **302**); and a street address where the provisioning entity is located (e.g., street address sub-category **358**; 234 University Ave. for record **301**; unknown for record **302**).

Type of provisioning entity category **360** can identify a type of the provisioning entity involved in each record. In some embodiments, type of provisioning entity category **360** of the provisioning entity can be identified by a category name customarily used in the industry (e.g., Gas Station for record **301**) or by an identification code that can identify a type of the provisioning entity (e.g., TPE**123** for record **303**). Alternatively, type of the provisioning entity category **360** can include a merchant category code ("MCC") used by credit card companies to identify any business that accepts one of their credit cards as a form of payment. For example, MCC can be a four-digit number assigned to a business by credit card companies (e.g., American Express™, MasterCard™, VISA™) when the business first starts accepting one of their credit cards as a form of payment.

In some embodiments, type of provisioning entity category **360** can further include a sub-category (not shown in FIG. **3**), for example, type of provisioning entity sub-category **361** that can further identify a particular sub-category of provisioning entity. For example, an record can comprise a type of provisioning entity category **360** as a hotel and type of provisioning entity sub-category **361** as either a bed and breakfast hotel or a transit hotel. It will be understood that the above-described examples for type of provisioning entity category **360** and type of provisioning entity sub-category **361** are non-limiting and that second list **150** can include other kinds of such categories and sub-categories associated with an record.

Record amount category **370** can represent a transaction amount (e.g., $74.56 for record **301**) involved in each record. Time of record category **380** can represent a time at which the record was executed. In some embodiments, time of record category **380** can be represented by a date (e.g., date sub-category **382**; Nov. 23, 2013, for record **301**) and time of the day (e.g., time sub-category **384**; 10:32 AM local time for record **301**). Time sub-category **384** can be represented in either military time or some other format. Alternatively, time sub-category **384** can be represented with a local time zone of either provisioning entity location category **350** or consuming entity location category **330**.

In some embodiments, each record data can include categories of information including (not shown in FIG. **3**), for example, consuming entity loyalty membership category, consuming entity credit card type category, consuming entity age category, consuming entity gender category, consuming entity income category, consuming entity with children category, product information category, and service information category.

Consuming entity loyalty membership category can represent whether the consuming entity is part of a loyalty membership program associated with a provisioning entity. For example, consuming entity loyalty membership category can represent that the consuming entity is a member of one of Costco™ membership programs including Gold-star Member™, Executive Member™, and Business Member™. Consuming entity credit card type category can represent the type of credit card used by the consuming entity for a particular record. For example, consuming entity credit card type category can represent that the credit card used by the consuming entity for that particular record can be one either American Express™, MasterCard™, VISA™, or Discover™ credit cards. In some embodiments, consuming entity credit card type category can represent a kind of MasterCard™ (e.g., Gold MasterCard™ or Platinum MasterCard™) used for a particular record.

In some embodiments, consuming entity demographic information can be stored in each record. For example, consuming entity demographic information can include at least one of: consuming entity age category, consuming entity gender category, consuming entity income category, and consuming entity with children category. In some embodiments, consuming entity age category can represent age information associated with the consuming entity; consuming entity gender category can represent gender information (e.g., Male or Female) associated with the consuming entity; consuming entity income category can represent income information (e.g., greater than $100,000 per year) associated with the consuming entity; and consuming entity with children category can represent whether the consuming entity has any children under 18 or not. For example, if the consuming entity has children under 18, a positive indication can be stored and if the consuming entity does not has children under 18, a negative indication can be stored. In some embodiments, consuming entity with children category can store information representing a number of children associated with the consuming entity.

Product information category can represent information associated with a product that is involved in an record. For example, product information category can represent that the product involved in the record is a particular type of product based on a stock keeping unit ("SKU") of the product. In some embodiments, the product's SKU can be unique to a particular provisioning entity involved in that particular record. Alternatively, product information category can represent the product involved in the record with a at least one of a Universal Product Code, International Article Number, Global Trade Item Number, and Australian Product Number. Service information category can represent information associated with a service that is involved in an record. For example, service information category can represent that the service involved in the record is a particular type of service based on an SKU of the service. It will be appreciated that an SKU can uniquely represent either a product or a service. Some examples of services can be warranties, delivery fees, installation fees, and licenses.

FIG. **4** is a block diagram of an exemplary computer system **400**, consistent with embodiments of the present disclosure. Components of system **100**, such as entity resolution system **120**, and client **110**, can include the architecture based on or similar to that of computer system **400**.

As illustrated in FIG. **4**, computer system **400** can include a bus **402** or other communication mechanism for communicating information, and one or more hardware processors **404** (denoted as processor **404** for purposes of simplicity) coupled with bus **402** for processing information. Hardware processor **404** can be, for example, one or more general-purpose microprocessors or it can be a reduced instruction set of one or more microprocessors.

Computer system **400** also includes a main memory **406**, such as a random access memory (RAM) or other dynamic storage device, coupled to bus **402** for storing information and instructions to be executed by processor **404**. Main memory **406** also can be used for storing temporary variables or other intermediate information during execution of instructions to be executed by processor **404**. Such instructions, after being stored in non-transitory storage media accessible to processor **404**, render computer system **400** into a special-purpose machine that is customized to perform the operations specified in the instructions.

Computer system **400** further includes a read only memory (ROM) **408** or other static storage device coupled to bus **402** for storing static information and instructions for processor **404**. A storage device **410**, such as a magnetic disk, optical disk, or USB thumb drive (Flash drive), etc. is provided and coupled to bus **402** for storing information and instructions.

Computer system **400** can be coupled via bus **402** to a display **412**, such as a cathode ray tube (CRT), liquid crystal display, or touch screen, for displaying information to a computer user. An input device **414**, including alphanumeric and other keys, is coupled to bus **402** for communicating information and command selections to processor **404**. Another type of user input device is cursor control **416**, such as a mouse, a trackball, or cursor direction keys for communicating direction information and command selections to processor **404** and for controlling cursor movement on display **412**. The input device typically has two degrees of freedom in two axes, a first axis (for example, x) and a second axis (for example, y), that allows the device to specify positions in a plane. In some embodiments, the same direction information and command selections as cursor control can be implemented via receiving touches on a touch screen without a cursor.

Computing system **400** can include a user interface module to implement a graphical user interface that can be stored in a mass storage device as executable software codes that are executed by the one or more computing devices. This and other modules can include, by way of example, components, such as software components, object-oriented software components, class components and task components, processes, functions, fields, procedures, subroutines, segments of program code, drivers, firmware, microcode, circuitry, data, databases, data structures, tables, arrays, and variables.

In general, the word "module," as used herein, refers to logic embodied in hardware or firmware, or to a collection of software instructions, possibly having entry and exit points, written in a programming language, such as, for example, Java, Lua, C or C++. A software module can be compiled and linked into an executable program, installed in a dynamic link library, or written in an interpreted programming language such as, for example, BASIC, Perl, or Python. It will be appreciated that software modules can be callable from other modules or from themselves, and/or can be invoked in response to detected events or interrupts. Software modules configured for execution on computing devices can be provided on a computer readable medium, such as a compact disc, digital video disc, flash drive, magnetic disc, or any other tangible medium, or as a digital download (and can be originally stored in a compressed or installable format that requires installation, decompression, or decryption prior to execution). Such software code can be

stored, partially or fully, on a memory device of the executing computing device, for execution by the computing device. Software instructions can be embedded in firmware, such as an EPROM. It will be further appreciated that hardware modules can be comprised of connected logic units, such as gates and flip-flops, and/or can be comprised of programmable units, such as programmable gate arrays or processors. The modules or computing device functionality described herein are preferably implemented as software modules, but can be represented in hardware or firmware. Generally, the modules described herein refer to logical modules that can be combined with other modules or divided into sub-modules despite their physical organization or storage.

Computer system **400** can implement the techniques described herein using customized hard-wired logic, one or more ASICs or FPGAs, firmware and/or program logic which in combination with the computer system causes or programs computer system **400** to be a special-purpose machine. According to some embodiments, the operations, functionalities, and techniques and other features described herein are performed by computer system **400** in response to processor **404** executing one or more sequences of one or more instructions contained in main memory **406**. Such instructions can be read into main memory **406** from another storage medium, such as storage device **410**. Execution of the sequences of instructions contained in main memory **406** causes processor **404** to perform the process steps described herein. In alternative embodiments, hard-wired circuitry can be used in place of or in combination with software instructions.

The term "non-transitory media" as used herein refers to any non-transitory media storing data and/or instructions that cause a machine to operate in a specific fashion. Such non-transitory media can comprise non-volatile media and/or volatile media. Non-volatile media can include, for example, optical or magnetic disks, such as storage device **410**. Volatile media can include dynamic memory, such as main memory **406**. Common forms of non-transitory media can include, for example, a floppy disk, a flexible disk, hard disk, solid state drive, magnetic tape, or any other magnetic data storage medium, a CD-ROM, any other optical data storage medium, any physical medium with patterns of holes, a RAM, a PROM, and EPROM, a FLASH-EPROM, NVRAM, any other memory chip or cartridge, and networked versions of the same.

Non-transitory media is distinct from, but can be used in conjunction with, transmission media. Transmission media can participate in transferring information between storage media. For example, transmission media can include coaxial cables, copper wire and fiber optics, including the wires that comprise bus **402**. Transmission media can also take the form of acoustic or light waves, such as those generated during radio-wave and infra-red data communications.

Various forms of media can be involved in carrying one or more sequences of one or more instructions to processor **404** for execution. For example, the instructions can initially be carried on a magnetic disk or solid state drive of a remote computer. The remote computer can load the instructions into its dynamic memory and send the instructions over a telephone line using a modem. A modem local to computer system **400** can receive the data on the telephone line and use an infra-red transmitter to convert the data to an infra-red signal. An infra-red detector can receive the data carried in the infra-red signal and appropriate circuitry can place the data on bus **402**. Bus **402** carries the data to main memory **406**, from which processor **404** retrieves and executes the instructions. The instructions received by main memory **406** can optionally be stored on storage device **410** either before or after execution by processor **404**.

Computer system **400** can also include a communication interface **418** coupled to bus **402**. Communication interface **418** can provide a two-way data communication coupling to a network link **420** that can be connected to a local network **422**. For example, communication interface **418** can be an integrated services digital network (ISDN) card, cable modem, satellite modem, or a modem to provide a data communication connection to a corresponding type of telephone line. As another example, communication interface **418** can be a local area network (LAN) card to provide a data communication connection to a compatible LAN. Wireless links can also be implemented. In any such implementation, communication interface **418** can send and receives electrical, electromagnetic or optical signals that carry digital data streams representing various types of information.

Network link **420** can typically provide data communication through one or more networks to other data devices. For example, network link **420** can provide a connection through local network **422** to a host computer **424** or to data equipment operated by an Internet Service Provider (ISP) **426**. ISP **426** in turn can provide data communication services through the world wide packet data communication network now commonly referred to as the "Internet" **428**. Local network **422** and Internet **428** can both use electrical, electromagnetic or optical signals that carry digital data streams. The signals through the various networks and the signals on network link **420** and through communication interface **418**, which carry the digital data to and from computer system **400**, can be example forms of transmission media.

Computer system **400** can send messages and receive data, including program code, through the network(s), network link **420** and communication interface **418**. In the Internet example, a server **430** can transmit a requested code for an application program through Internet **428**, ISP **426**, local network **422** and communication interface **418**. The received code can be executed by processor **404** as it is received, and/or stored in storage device **410**, or other non-volatile storage for later execution. In some embodiments, server **430** can provide information for being displayed on a display.

FIG. **5** is a box diagram representing an exemplary process for associating related records to common entities across multiple lists, consistent with embodiments of the present disclosure. The dotted region, labelled **120**, represents an exemplary entity resolution system (e.g., entity resolution system **120** in FIG. **1**). The exemplary process can acquire two lists on the order of millions of records (e.g., first list **140** and second list **150**) and determine whether records in each list are related. The process can be used for at least one of data enrichment, data integration, and data duplication. Data enrichment refers to processes used to enhance, refine or otherwise improve raw data. Data integration involves combining data residing in different sources and providing users with a unified view of these data. Data duplication refers to determining whether a particular list has duplicate entries. While FIG. **5** provides an exemplary process flow for some embodiments of the present disclosure, it should be recognized by a person of skill in the art that not all steps need to be taken and that there can be additional steps.

As shown in FIG. **5**, entity resolution system **120** can receive first list **140** and second list **150**, which were

described above in FIGS. **1-3**. Entity resolution system **120** can then process first list **140** using a first cleaner **510** and a first blocker **520**.

First cleaner **510** can apply one or more cleaning functions to first list **140**. Exemplary cleaning functions can include making alphanumeric characters in each field lowercase, taking out punctuation from a field, taking out all numbers in a field, taking out everything but the numbers in the field, or switching "St" for "Street" or vice versa. Cleaning functions can be applied to the data in one or more fields in each record of first list **140**. The cleaning functions can be used to normalize all of the records so that other functions can be more easily applied to first list **140**. One or more cleaning functions can be chosen or determined automatically, by a user, or a combination thereof.

To illustrate the application of a particular cleaning function, a field can comprise a phone number of (987) 654-3210. A cleaning function can be applied to the field that would only keep the numbers, resulting in the field comprising 9876543210. Thus, when this field is compared with another field that has a similar cleaning function applied to it, there will only be numbers to compare. Another cleaning function that can be applied would be to add a number in front of the phone number. An example would be adding the number 1. The result of this cleaning function would be the field comprising 19876543210.

As shown above, after a cleaning function is applied, the data in the record of first list **140** can be altered by the cleaning function. In some embodiments, the data in the record of first list **140** will not be altered directly; but instead, either indicate that such cleaning function should be applied to the particular one or more fields in the future or associate the cleaned field with the original field in the first list **140**. In some embodiments, the data in the record of first list **140** will not be altered at all; but instead, a new list will be created that includes the records with the cleaned fields.

After first list **140** has been cleaned in first cleaner **510**, the cleaned records of first list **140** are provided to first blocker **520**. First blocker **520** can reduce the number of comparisons necessary to determine if two records are related to a similar entity by reducing the number of relevant records. First blocker **520** assigns one or more records of first list **140** to one or more groups based on one or more fields. For example, an assignment can be based on phone number. In this example, if the phone number of a record in first list **140** matches the phone number of another record in first list **140**, the two records would be assigned to the same group. Further, a record may not have a match; and thus would be assigned to a group comprising of itself.

An example of an assignment to a group based on one more than one field would be as follows. The assignment can be based on both the phone number and address. In this example, a record would only be put into a group with another record if both records have the same phone number and address.

In some embodiments, assignments can be based on a portion of a field. For example, an assignment to a group can be based on the first three numbers of a phone number. Thus, every record with the same first three numbers would be assigned to a particular group.

The group having the assigned records can be defined by a new list having those assigned records or by a number of pointers or other associations linking those assigned records to the group.

Entity resolution system **120** can also process second list **150** using a second cleaner **515** and a second blocker **525**, which can provide similar functionality as those described above for first cleaner **510** and first blocker **520**. While second cleaner **515** and second blocker **525** can provide similar functionality (e.g., cleaning and blocking), the application of that functionality may be different and may depend on how the data is stored in the fields of second list **150**. For example, the field comprising (987) 654-3210 in first list **140** may be represented as 19876543210 in second list **150**. For purposes of matching the data in the fields, it may be appropriate to clean or format the data so that the formatting of the data is consistent across both lists. If the desired end result is to compare a string of ten numbers, the field comprising (987) 654-3210 would need to have a cleaning function that removes everything but the numbers and the field comprising 19876543210 would need a cleaning function that removes the 1 from the front of the number.

Moreover, while FIG. **5** depicts two cleaners and two blockers, it is appreciated that only one cleaner and blocker may be used, wherein the cleaner and blocker each provide different instances based on whether the received input is the acquired first list **140** or the acquired second list **150**. It is also appreciated that entity resolution system **120** does not include one or more cleaners as the formatting of data between first list **140** and second list **150** are consistent. Moreover, it is appreciated that cleaning can take place after blocking or pair generation.

After one or more records from first list **140** and second list **150** have respectively been assigned to one or more groups, entity resolution system **120** uses a pair generator **530** to process at least one group from first list **140** and at least one group from second list **150**. Pair generator **530** can associate a record of the one or more groups from first list **140** with a record of a group in the one or more groups from second list **150**, as further explained in FIG. **7**. The respective groups of each record can be chosen because the one or more fields that the groups were grouped by were similar.

To pair these groups, pair generator **530** can perform a Cartesian product of the two groups. For example, a first group can comprise a first record and a second record while a second group can comprise a third record and a fourth record. The Cartesian product of the first group and the second group would be the entire first record with the entire third record, the entire first record with the entire fourth record, the entire second record with the entire third record, and the entire second record with the entire fourth record. The Cartesian product can also only pair relevant fields of each of the records rather than the entire records. Relevant fields can be determined through the blocking functions or some other determination.

Pairing can be accomplished with a separate data structure that comprises the two records that are paired together. Pairing can also be accomplished by associating the two records that are paired together without moving them to a new data structure.

In some embodiments, entity resolution system **120** can be split across one or more networked computers, communicatively coupled via a network (e.g., network **160**). In some embodiments, the networked computers can be organized into a distributed computing architecture. For example, the distributed computing architecture can be a system such as Apache Hadoop. In these embodiments, for example, blocking functions (e.g., the blocking functions provided by first blocker **520** or second blocker **525**) can run in parallel across the distributed clusters and can generate output keys for each record for use by pair generator **530**. In some embodiments pair generator **530** and the remaining portions of entity resolution system **120** can continue on a single networked computer.

The paired lists are then processed in a feature evaluator **540**. Feature evaluator **540** can evaluate a pair based on one or more of the fields in the records of the pair. The evaluation can be in the form of a numeric score or other evaluation type. The evaluation can be based on a computer generated or user specified function. For example, a pair can be evaluated by the difference in length of its first field. If the first field of the first record in the pair is "Trader Joes" and the first field of the second record in the pair is "Trader Jose," the evaluation by the difference in length of its first field would be 0.

Feature evaluator **540** can also evaluate a pair based on information that is external to either record in the pair, for example a distance between the addresses identified in each record of the pair. In this example, two records may have a field that represents an address. An evaluation can send the addresses to a separate process that calculates the distance between the two addresses. This kind of information is known as a global feature. A global feature can be added to a number of places, including the records of first list **140**, the records of second list **150**, a pair, or any combination thereof. The addition of global features can also occur at a number of places, including: before a list is in entity resolution system **120**, when a list is in either first cleaner **510** or second cleaner **515**, when a list is in first blocker **520** or second block **525**, when a group is in pair generator **530**, when a record is in feature evaluator **540**, or any combination thereof.

Feature evaluator **540** can evaluate a pair one or more times. The one or more evaluation functions may or may not indicate similarity between the records. For example, an evaluation can be the number of words in a particular field. While such an evaluation may not indicate similarity between the records, this type of valuation may still be used in combination with other evaluations to determine similarity between the records.

After one or more evaluation functions are performed by feature evaluator **540**, the one or more evaluations are associated with the pair that they are based on. The associations can be through a data structure that holds both records in the pair and the one or more evaluations. The associations can also be metadata or an indicator in the pair that points to the evaluations.

The pairs with the one or more evaluations can then be passed to a trainer **550**, a record assessor **560**, or some combination thereof. The trainer **550** can create a statistical model that can be applied in record assessor **560** to the pairs with the one or more evaluations. The statistical model can ultimately determine if a particular record is related to another record. A statistical model can also just be passed to record assessor **560**, effectively bypassing trainer **550**. A statistical model can be created through a machine learning model in trainer **550** based on a portion or all of the pairs with the one or more evaluations. The machine learning model can also be based on data not in the pairs or on past data of similar pairs.

The machine learning model can be a supervised, semi-supervised, unsupervised machine learning technique, or some combination thereof.

A supervised machine learning technique can require a user or some other information source to label each pair that the machine learning model can rely on. Labeling can come in many forms, including a binary indicator of matching or not matching, likelihood that the two records in the pair represent a similar entity, or some other indicator that would aid in determining whether two records are related to a similar entity. Examples of a supervised machine learning technique include decisions trees, bagging, boosting, and random forest.

A semi-supervised machine learning technique can reduce the number of pairs that a user or some other information source needs to label. An example of a semi-supervised machine learning technique is active learning. Active learning can involve inspecting the pairs and/or their corresponding evaluations to determine which one or more pairs entity resolution system **120** should inquire about. This inquiry can be provided to a user or some other information source so that one or more of these information sources can provide an input or label to the pair. The input or label can represent whether the user or some other information source deduces that the records of the pair are related to a similar entity. After the entity resolution system **120** receives labels for the one or more pairs, the machine learning model can show the user or other information source one or more other available pairs for labelling.

After the machine learning model has received, for example, a matching and non-matching label, the machine learning model can either show more pairs to the user or other information source or automatically label the remaining pairs. Examples of techniques to automatically label the remaining pairs include linear and logistic regression. A pair is informative to the machine learning model if it assists the machine learning model in determining whether two records are related to the same entity and can be based on the one or more evaluations that have been made on the pairs by feature evaluator **540**.

In some embodiments, using the active learning approach, a matching and non-matching suggestion can be more easily recognized by the machine learning model in the beginning by taking the highest combined evaluations and the lowest combined evaluations for the first field in a record. This can increase the likelihood that the records shown to the user are a matching and not matching.

An unsupervised learning technique allows for no interaction from a user or other information source. Examples of an unsupervised machine learning technique include clustering.

In some embodiments, a trainer **550** can take a sample of the pairs from feature evaluator **540**. The sample can be chosen by an algorithm, a user, randomly, or any combination thereof. There is no set size the sample must be. Some samples can be the size of the available memory. Other samples can be set at a specific number, for example 10,000 pairs. Still further, other samples can be set as a number that is determined by a function or process. When using a sample, a machine learning model can label the pairs in the sample or a portion of the pairs in the sample to create the statistical model.

The statistical model can output a score that represents the likelihood that the records in each pair are related to a similar entity. The score may be a number between 1 and 0, with 1 representing 100% likelihood that the records in the pair are related to the same entity and 0 representing 0% likelihood that the records in the pair are related to the same entity.

As was previously discussed, record assessor **560** receives the pairs with one or more evaluations from feature evaluator **540** associated with them and the statistical model in order to assess the likelihood that the records in each pair are related to a similar entity. Record assessor **560** applies the statistical model to the one or more evaluations of each pair. Because the sample of pairs has already been trained to the

records, the process of scoring new pairs can be accomplished with relative ease using the statistical model.

Because trainer **550** can be based on pairs it has already seen, new pairs that are processed in record assessor **560** can update the statistical model to incorporate new records that it sees. Updates to the statistical model allow for increased precision of the system over time.

After the assessment in record assessor **560**, the pairs with the scores can be filtered in a filter **570**. Filtering can distinguish pairs that have a match probability above a certain threshold. Distinguishing the pairs can comprise of indicating in the records that they are associated with other records. Distinguishing can also comprise of gathering the pairs that have a match probability above a certain threshold in a data structure. The threshold can be user specified or automatically generated based on the output of record assessor **560**.

After the pairs are distinguished in filter **570**, filter **570** can provide a result based on the filtering. The result can be provided in a number of ways, for example, such as showing one or more matching records, a probability that the pair is associated with the same entity, or any combination thereof.

The result of filter **570** can also be used to resolve matching entities. Resolving matching entities may comprise combining records that are associated with the same records. Resolving matching entities can also comprise of grouping matching records into sets.

After the filtering stage, there can be a global optimization that would use matches between first list **140** and second list **150** to find a match in first list **140** or multiple matches of one record in first list **140** with second list **150**.

Similarly to the system, a method can be used to associate related records to common entities across multiple lists. FIG. **6** is a flowchart representing an exemplary method for associating related records to common entities across multiple lists, consistent with embodiments of the present disclosure. While the flowchart discloses the following steps in a particular order, it will be appreciated that at least some of the steps can be moved, modified, or deleted where appropriate, consistent with the teachings of the present disclosure. The associating can be performed in full or in part by an entity resolution system (e.g., entity resolution system **120**). It is appreciated that some of these steps can be performed in full or in part by other components (e.g., such as client **110** identified above in FIG. **1**).

FIG. **6** starts with acquiring a first list (e.g. first list **140**) and a second list (e.g. second list **150**), as shown in step **610**. The first list and the second list can both comprise a plurality of records that each comprise one or more fields. The records of the first list are grouped into one or more first groups based on one or more fields of each record, as shown in step **620**. The records of the second list are grouped into one or more second groups based on one or more fields of each record, as shown in step **630**. The first groups and the second groups can be based on different one or more fields of each record. A record in a first group is paired with all of the records in a second group, as shown in step **640**. When two groups are paired together, the respective groups can be similar. Similarity can be based on how the groups were initially formed. Thus, two similar groups can occur when a first group was based on one or more fields that are similar to the one or more fields a second group was based on. Further, the pairing can be based on a Cartesian product, as described above. After the pairing, a pair is evaluated one or more times, as shown in step **650**. An evaluation of a pairs can be based on at least a portion of the record of the first group and at least a portion of the record of the second group. After the evaluations, the records of a pair are associated with an entity based on an assessment of the one or more evaluations of the pair, as shown in step **660**.

FIG. **7** is a flowchart representing an exemplary method **700** for pairing one or more records of a first group with one or more second groups, consistent with embodiments of the present disclosure. Pairing step **640** of FIG. **6** can be implemented using pairing method **700**. While the flowchart discloses the following steps in a particular order, it will be appreciated that at least some of the steps can be moved, modified, or deleted where appropriate, consistent with the teachings of the present disclosure. The pairing can be performed in full or in part by an entity resolution system (e.g., entity resolution system **120**). It is appreciated that some of these steps can be performed in full or in part by other components (e.g., such as client **110** identified above in FIG. **1**).

First, an unpaired record of a first group and a second group are acquired, as shown in step **710**. The second group can comprise one or more records that have not been previously paired. The first group can be based on similar one or more fields to the one more fields that the second group is based on. The unpaired record of the first group is paired with an unpaired record of the second group, as shown in step **720**. Next, a determination is made regarding whether there is another unpaired record of the second group, as shown in step **730**. If there is another unpaired record of the second group, the method goes back to step **720**. If there is not another unpaired record of the second group, the method proceeds to step **740**. In step **740**, a determination is made regarding whether there is another unpaired record of the first group. If another unpaired record of the first group exists, the method can proceed to step **710**. If, however, there is not another unpaired record of the first group, the method ends.

FIG. **8** is a flowchart representing an exemplary method **800** for evaluating and assessing one or more pairs, consistent with embodiments of the present disclosure. Evaluating step **650** and associating step **660** of FIG. **6** can be implemented using method **800**. While the flowchart discloses the following steps in a particular order, it will be appreciated that at least some of the steps can be moved, modified, or deleted where appropriate, consistent with the teachings of the present disclosure. Method **800** can be performed in full or in part by an entity resolution system (e.g., entity resolution system **120**). It is appreciated that some of these steps can be performed in full or in part by other components (e.g., such as client **110** identified above in FIG. **1**).

First, a list of one or more pairs is acquired, as shown in step **810**. The pairs can each comprise a first record and a second record. The first record and the second record may not include all of the fields of the respective records, but instead can include only the one or more fields that will be evaluated and assessed. The pair can then be evaluated by a function that is predefined either by a user or computer process, as shown in step **820**. The evaluation can be any measurement of one or more fields of the records, including number of letters and number of words. The measurement may take the form of an enumerated class or of a numerical value. After the pair has been evaluated, the method of **800** includes associating the evaluation with the pair and determining if there is another function to evaluate the pair, as shown in step **830**. If there is another function, the method will revert back to step **820**. This allows for multiple evaluations to be conducted on a single pair. Each additional evaluation can be either further associated with the pair or combined with the previous one or more evaluations. After

there are no more functions to apply to the pair, the method will assess the pair based on the one or more evaluations, as shown in step **840**.

The method of **800** can be stepped through for each pair at a time. For example, a pair is evaluated by the one or more evaluations and then assessed based on the one or more evaluations. Also, a pair can be evaluated with two or more records at a time. For example, both a first pair and a second pair is evaluated either respectively or together with functions and then assessed either individually or together in step **840**. The pair can also be evaluated and assessed in parallel.

Embodiments of the present disclosure have been described herein with reference to numerous specific details that can vary from implementation to implementation. Certain adaptations and modifications of the described embodiments can be made. Other embodiments can be apparent to those skilled in the art from consideration of the specification and practice of the embodiments disclosed herein. It is intended that the specification and examples be considered as exemplary only, with a true scope and spirit of the present disclosure being indicated by the following claims. It is also intended that the sequence of steps shown in figures are only for illustrative purposes and are not intended to be limited to any particular sequence of steps. As such, it is appreciated that these steps can be performed in a different order while implementing the exemplary methods or processes disclosed herein.

What is claimed is:

1. A system for associating records across a first list and a second list to a common entity, the system comprising:

one or more memory devices that store:

a set of instructions; and

a first list and a second list, wherein the first list and the second list both include a plurality of records, and wherein each of the plurality of records is associated with a respective entity and includes one or more fields;

one or more processors configured to execute the set of instructions that cause the one or more processors to:

group, into a first group, one or more records of the first list based on one or more fields of the records of the first list;

group, into a second group, one or more records of the second list based on one or more fields of the records of the second list;

pair a record of the one or more records of the first group with a record of the one or more records of the second group;

assess each pair of the one or more pairs based on an evaluation of the respective pair according to one or more fields of the pair; and

associate one or more records of the first group and one or more of the records of the second group with an entity based on the assessment.

2. The system of claim **1**, wherein the group of records of the first group and the group of records of the second group are based on similar one or more fields.

3. The system of claim **1**, wherein the assessment is based on one or more evaluations.

4. The system of claim **1**, where the assessment is trained based on the one or more evaluations.

5. The system of claim **1**, wherein the assessment of a first record and a second record of the pair is at least partially based on information that is external to the first record and the second record of the pair.

6. The system of claim **1**, further comprising one or more processors configured to execute a set of instructions that cause the one or more processors to associate one or more records of the first group with one or more other records of the first group based on the one or more assessments of a pair.

7. The system of claim **1**, wherein at least one of the first list and the second list is cleaned before the at least one of the first list and the second list is grouped.

8. A method for associating records across a first list and a second list to a common entity, the method comprising:

obtaining a first list and a second list, wherein the first list and the second list both include a plurality of records, and wherein each of the plurality of records is associated with a respective entity and includes one or more fields;

grouping a record of the plurality of records of the first list into one or more first groups based on one or more fields of the record;

grouping a record of the plurality of records of the second list into one or more second groups based on one or more fields of the record;

pairing a record of the first group with a record of the second group, wherein the record of the first group and the record of the second group were grouped respectively based on similar one or more fields;

evaluating, one or more times, a pair;

associating, with an entity, the records of a pair, wherein the association is based on assessing the one or more evaluations of the pair.

9. The method of claim **8**, wherein the grouping of records of the first group and the grouping of records of the second group are based on similar one or more fields.

10. The method of claim **8**, where associating is trained based on the one or more evaluations.

11. The method of claim **8**, wherein assessing a first record and a second record of the pair is at least partially based on information that is external to the first record and the second record of the pair.

12. The method of claim **8**, further comprising of associating one or more records of the first group with one or more other records of the first group based on evaluating the pair.

13. A non-transitory computer-readable medium storing a set of instructions that are executable by one or more processors to cause the one or more processors to perform a method to associate related records across a first list and a second list to a common entity, the method comprising:

obtaining a first list and a second list, wherein the first list and the second list both include a plurality of records, and wherein each of the plurality of records is associated with a respective entity and includes one or more fields;

grouping a record of the plurality of records of the first list into one or more first groups based on one or more fields of the record;

grouping a record of the plurality of records of the second list into one or more second groups based on one or more fields of the record;

pairing a record of the first group with a record of the second group, wherein the record of the first group and the record of the second group were grouped respectively based on similar one or more fields;

evaluating, one or more times, a pair;

associating, with an entity, the records of a pair, wherein the association is based on assessing the one or more evaluations of the pair.

14. The non-transitory computer-readable medium of claim **13**, wherein the grouping of records of the first group

and the grouping of records of the second group are based on similar one or more fields.

15. The non-transitory computer-readable medium of claim **13**, where associating is trained based on the one or more evaluations.

16. The non-transitory computer-readable medium of claim **13**, wherein evaluating a first record and a second record of the pair is at least partially based on information that is external to the first record and the second record of the pair.

17. The non-transitory computer-readable medium of claim **13**, further comprising a set of instructions that are executable by one or more processors to cause the one or more processors to perform associating one or more records of the first group with one or more other records of the first group based on evaluating the pairs.

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